The transition from agricultural to industrial society: Japanese case

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The Transition from Agricultural to Industrial Society: Japanese Case *)

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I. Introduction

The relationship among technical change, population growth, and economic development are poorly understood. Also, Japan's success in economic development since the Meiji Restoration of 1868 continues to attract attention. In this paper an attempt is made to measure the effects of differential rates of technical change in the agricultural and nonagricultural sectors and of population growth on Japanese economic development in every decade for the period 1880 - 1970.

The model includes an agricultural sector and a nonagricultural sector. It extends conventional growth accounting to include intersectoral relationship and demand factors (population, per capita income, terms of trade, and imports/ exports) more directly. This tells the difference of the role of technical change, population growth, capital stock and other variables in the transition from agricultural to industrial society.

II. General Outline of Japanese Economic Development

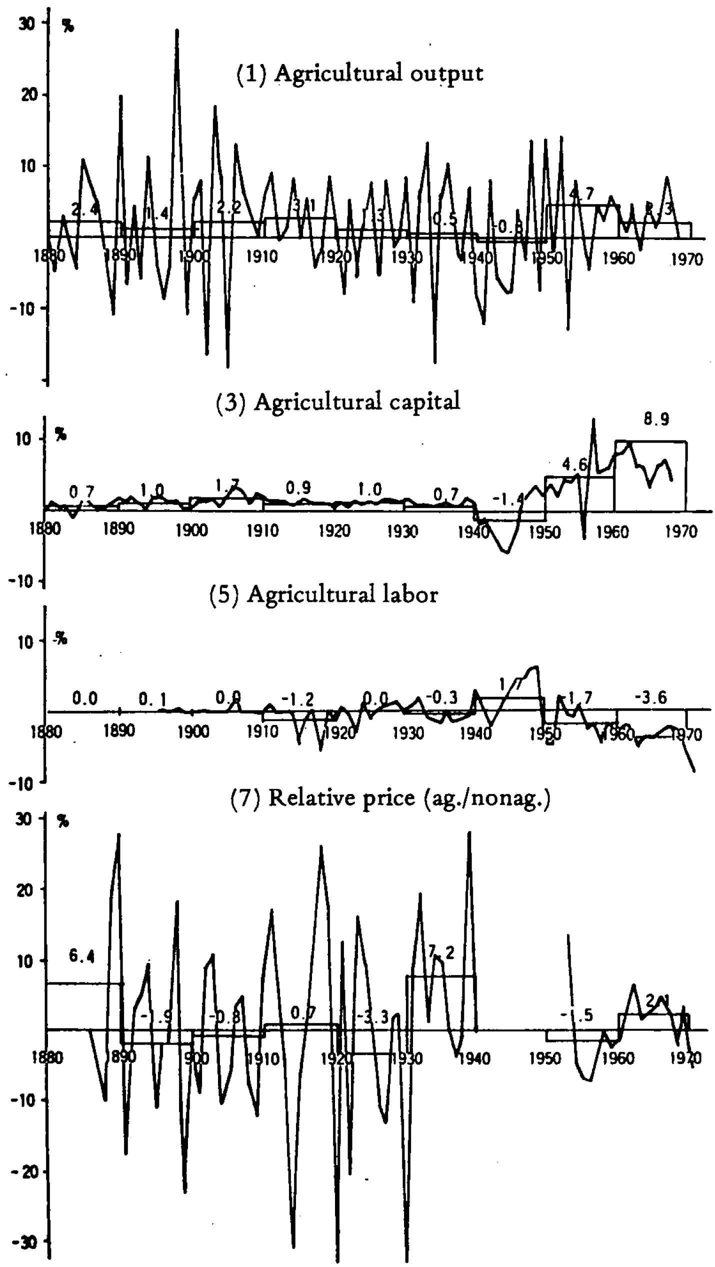
Figure 1 shows the annual growth rates of agricultural and nonagricultural outputs, inputs (the capital and labor in each sector), the relative price (agricultural price/ nonagricultural price) and per capita income for the period 1880 - 1970. These are the eight endogenous variables in our model which has the matrix form Ax=b. The histogram in Figure 1 also gives the historical average growth rate of each of the 8 endogenous variables in each decade. For example, the value of the nonagricultural output in the 1880's shows 4.3 %. This means that real nonagricultural output grew at the rate of 4.3 % between 1880 and 1890. Figure 1 also shows that the growth rate of per capita income (in real term) accelerated over time. This would indicate the phenomena of the trend acceleration of the Japanese economy, pointed out by Ohkawa and Rosovsky (2). Note that the trend acceleration is especially apparent after World War II. On the other hand when we observe the annual growth rates for the variables we find numerous wave motions causing the long-term wave motions in the moving-average of the annual growth rate of each variable.

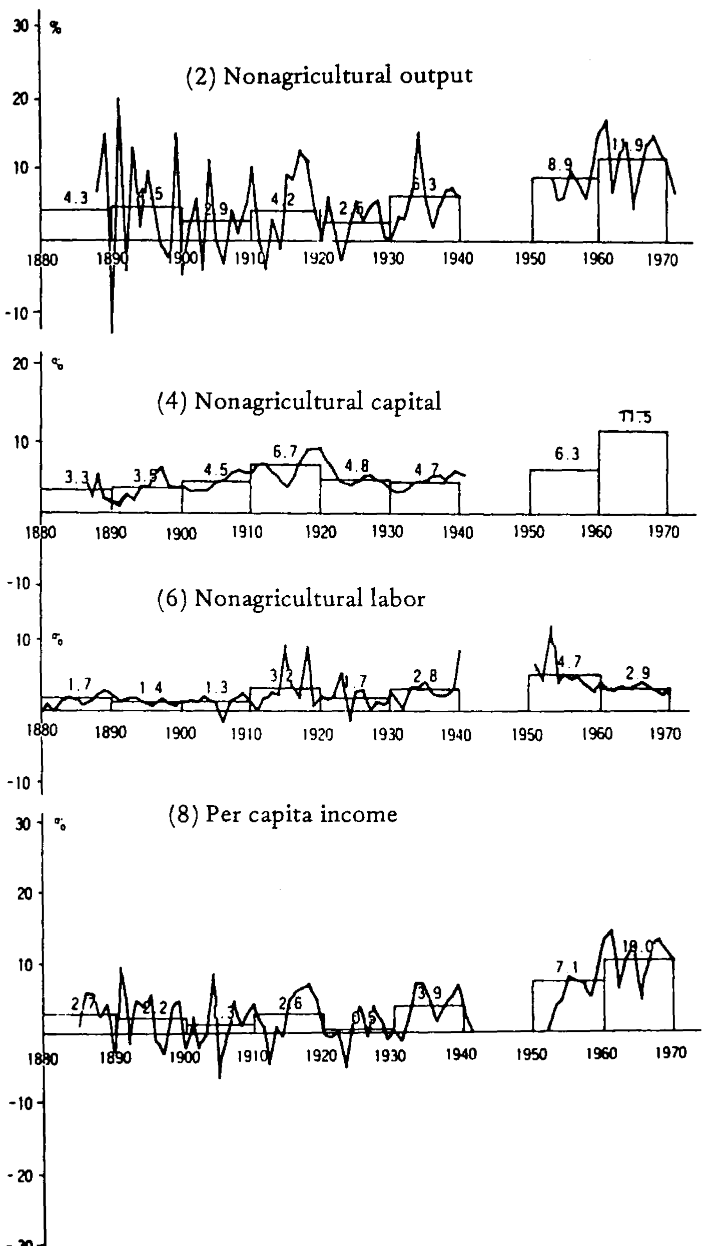
Let us now consider the depression periods in the Japanese economy. Figure 1 shows that the growth rates of per capita income and nonagricultural output

*) This paper is a summary and extension of Yamaguchi (4), (5), (6), (7). Therefore, we draw very heavily from these four papers although we recalculated the result by using a new data.

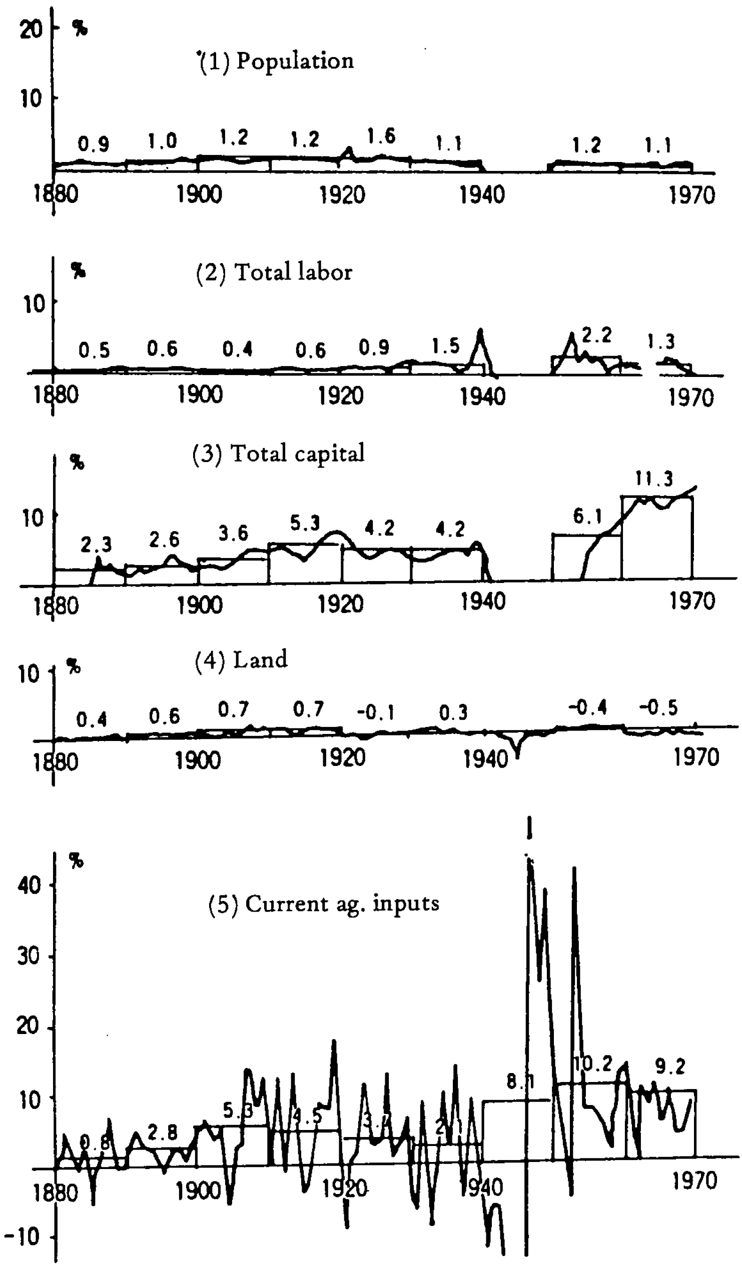
Figure 1: Annual Growth Rate of Endogenous and Exogenous Variables

Enodenous variables

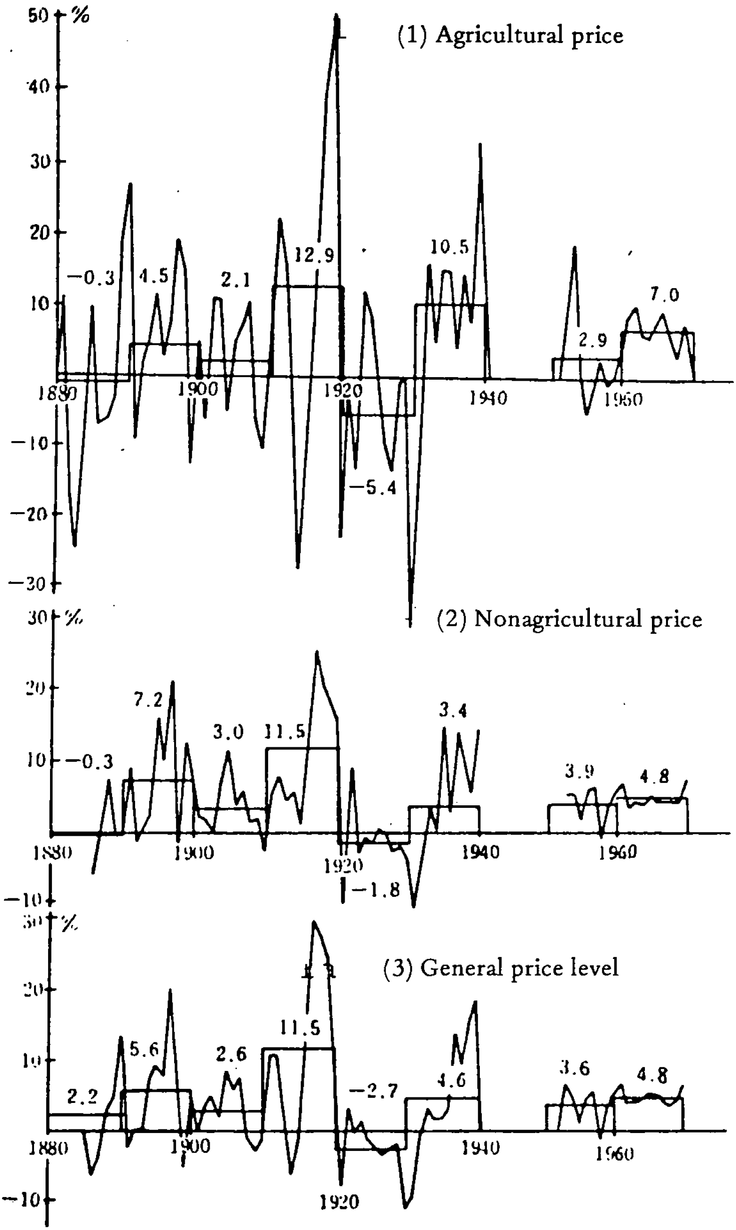



(2) Nonagricultural output
%
30
20
10
-10
4.3
4.5
2.9
4.2
2.6
6.3
8.9
11.9
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
(4) Nonagricultural capital
%
20
10
3.3
3.5
4.5
6.7
4.8
4.7
6.3
11.5
(6) Nonagricultural labor
%
10
-10
1.7
1.4
1.3
3.2
1.7
2.8
4.7
2.9
(8) Per capita income
%
30
20
10
-10
-20
-30
2.7
2.2
1.3
2.6
0.5
3.9
7.1
10.0

Exogenous variables



Price level



(1) Agricultural price
50
40
30
20
10
−10
−20
−30
%
−0.3
4.5
2.1
12.9
−5.4
10.5
2.9
7.0
1880
1900
1920
1940
1960
(2) Nonagricultural price
30
20
10
−10
%
−0.3
7.2
3.0
11.5
−1.8
3.4
3.9
4.8
1880
1900
1920
1940
1960
(3) General price level
30
20
10
−10
%
2.2
5.6
2.6
11.5
−2.7
4.6
3.6
4.8
1880
1900
1920
1940
1960

in the years 1890, 1898, 1900 - 1901, 1907 - 1908, the depression years, have zero or negative numerical values. However as a whole, the Japanese economy experienced strong development until 1919. Economic difficulties came after the year 1920; negative or zero growth rates of per capita income and nonagricultural output were experienced in the depression year of 1920, the Kanto earthquake of 1923, the monetary depression of 1927, the Great Depression of 1930, as Figure 1 indicates. Especially after the heavy crops of rice harvested in 1930, which is indicated by a large positive growth rate of the agricultural output and a large negative growth rate of the relative price (agricultural price/ nonagricultural price) in that year, there occurred an agricultural stagnation period which roughly corresponds to the period between the two World Wars.

If we compare the growth rates of each variable in the agricultural sector with those of the nonagricultural sector, the growth rates of output and inputs in the nonagricultural sector are much larger. Note especially that the growth rates of agricultural labor are zero or negative except during the depressions and between the two World Wars and become smaller (negative) after World War II, indicating the unequal development between agriculture and nonagriculture. The proportions of labor and capital employed in agriculture, and the share of income produced by agriculture which were 71, 43 and 50 % respectively in 1880 decreased to 16, 6 and 6 % respectively in 1970 (see Table 3).

Next observe the output growth of each sector. The variation in the output of agriculture was very large in the beginning of the whole period (the period of Meiji era) and decreased trendwise over time. This was due to the fact that agricultural technology was still in its infancy so that agricultural output was severely dependent on the weather and natural conditions. Note that the agricultural depression period which occurres in the 1930's rather than 1920's (the depression period of the Japanese economy as a whole) was characterized by very low growth rates of agricultural output and input. On the other hand nonagricultural output shows a pattern similar to that of per capita income and we can observe the trend acceleration as a whole and the depression period in the 1920's similarly. The variation in growth rates of nonagricultural output was fairly large in the beginning of the period. This stems from the fact that nonagricultural technology was still in the developing stage and was concentrated on fabrics, spinning and weaving which utilized the agricultural products as raw materials.

The agricultural sector shows a relatively smaller value in the uses of factor inputs than the nonagricultural sector. However agricultural labor decreased and agricultural capital increased (i.e., capital was substituted for labor) in Japanese agriculture, especially after World War II. It is also seen that the uses of nonagricultural labor increased but those of nonagricultural labor decreased and became negative in the depression periods and during the two World Wars.

The relative price of agricultural output shows the largest variation owing to the low price elasticity of agricultural products and the large variation in agricultural output. However the variation of this relative price decreased quite markedly after World War II, partly due to the agricultural price policy, the development of agricultural technology and the improvement of plant breeding. We can also observe in Figure 1 that in the year of rice riot (1918) agricultural products had an extremely high relative price.

The annual and decadal growth rate of the 5 principal exogenous variables in our model are also graphed in Figure 1; these are population, land, total labor, total capital and current agricultural inputs. The growth rates of population and labor are around 1 % and remain almost constant but note that the growth rates of labor and population are different in the short run. Population has a relatively high growth rate in the periods between 1900 - 1930 but labor has a relatively high growth rate in the 1930's and the 1950's. Land increased until 1920 but decreased sharply in the 1940's and again after 1960. Population, labor and land increased at fairly constant rates of 1.2, 0.9 and 0.2 % etc., while total capital and current agricultural inputs increased at much higher rates (about 5 or 6 % on the average over the entire period) even though their rates of increase slowed somewhat in the depressions. Generally speaking the growth rate of each exogenous variable has been fairly stable except for the growth rate of current agricultural inputs which fluctuated much more as Figure 1 shows.

III. Model and Data

The model is shown in Table 1. It is an agricultural and nonagricultural two sector model (see Yamaguchi (4), (5), (6), (7) in detail). Eight endogenous variables (Y_1, Y_2, K_1, K_2, L_1, L_2, P, E) and eight exogenous variables (K, L, Q, B, T_1, T_2, m_w) are listed in Table 2.

The static version of the model can be transformed into an eight-equation model of the form, Ax=b, where A is the matrix of structural parameters, x a vector of rates of change of the eight endogenous variables, and b a vector of rates of change of the exogenous variables. This system is summarized in Table 1, where dots on the variables denote growth rates.

The inverse of A displays growth rate multipliers (GRM). For example, the 8, 4 element of A^{-1} is the partial derivative $\partial \dot{E}/\partial \dot{L}$, which indicates by how much an increase in the growth rate of labor will increase the growth rate of per capita income.

Estimates of the parameters of the matrix A and the inverse GRM were obtained for five-year intervals from 1880 to 1965. Changes in the GRM trace structural changes in the economy.

Table 1 Static und Dynamic Versions of the Mathematical Model

Static model		
Equation No.	**Equation**	
(1)	$Y_1 = aQP^{\eta} E^{\epsilon}$	Agricultural demand function
(2)	$Y_1 = T_1 L_1^{\alpha} K_1^{\beta} B^{(1-\alpha-\beta)}$	Agricultural production function
(3)	$Y_2 = T_2 L_2^{\gamma} K_2^{\delta}$	Nonagricultural production function
(4)	$L_1+L_2=L$	Adding up constraint
(5)	$K_1+K_2=K$	
(6)	$w_1 = \alpha P_1 (Y_1/L_1)$	Value of marginal product equals factor price
(7)	$w_2 = \gamma P_2 (Y_2/L_2)$	
(8)	$r_1 = \beta P_1 (Y_1/K_1)$	
(9)	$r_2 = \delta P_2 (Y_2/K_2)$	
(10)	$w1=m_w w2$	Factor mobility condition
(11)	$r1=r2$	
(12)	$P_1Y_1+P_2Y_2=P'QE$	Income identity

m_w = agricultural wage rate as a proportion of nonagricultural wage rate
a = agricultural demand shifter
η,ϵ = agricultural price and income elasticity
α, β = output elasticity of agricultural labour and capital
γ, δ = output elasticity of nonagricultural labour and capital
λ = proportion of income generated in agriculture

Dynamic model

Equation no.	Coefficients of the A matrix of structural parameters								Vector x of endogenous variables	Vector b of exogenous variables
(13)	1	0	0	0	0	0	$-\eta$	$-\epsilon$	$\dot{Y}_1$	$\dot{a}+\dot{Q}$
(14)	1	0	$-\beta$	0	$-a$	0	0	0	$\dot{Y}_2$	$\dot{T}_1+(1-a-\beta)\dot{B}$
(15)	0	1	0	$-\delta$	0	$-\gamma$	0	0	$\dot{K}_1$	$\dot{T}_2$
(16)	0	0	0	0	1_1	1_2	0	0	$\dot{K}_2$	$\dot{L}$
(17)	0	0	κ_1	κ_2	0	0	0	0	$\dot{L}_1$	$\dot{K}$
(18)	0	0	1	-1	-1	1	0	0	$\dot{L}_2$	$\dot{m}_w$
(19)	0	0	$\beta-\delta$	0	$a-\gamma$	0	1	0	$\dot{P}$	$\dot{T}_2-\dot{T}_1-(1-a-\beta)\dot{B}+\gamma\dot{m}_w$
(20)	λ	$1-\lambda$	0	0	0	0	0	-1	$\dot{E}$	$\dot{Q}$

$i = 1,2$ = agricultural and nonagricultural sector, respectively
$Y_i, L_i, K_i . B$ = sectoral outputs, labour inputs, capital inputs, and agricultural land
P_1 = sectoral output prices
P = P_1/P_2 = terms of trade
P' = general price level
w_i, r_i = sectoral wage and capital rental rates
T_i = sectoral level of technical efficiency
Q = population
E = per capita income

Table 2: Average Annual Growth Rates of Endogenous and Exogenous Variables (Percentages)

	Endogenous variables							
	$\dot{Y}_1$	$\dot{Y}_2$	$\dot{K}_1$	$\dot{K}_2$	$\dot{L}_1$	$\dot{L}_2$	$\dot{P}$	$\dot{E}$
1880 - 1890	3.4	3.7	0.7	3.3	0.0	1.7	6.3	2.7
1890 - 1900	1.7	3.9	1.0	3.5	0.1	1.4	- 1.9	2.2
1900 - 1910	2.2	2.6	1.7	4.5	0.0	1.3	- 0.8	1.3
1910 - 1920	3.2	4.0	0.9	6.7	- 1.2	3.2	0.7	2.6
1920 - 1930	1.1	2.4	1.0	4.8	0.0	1.7	- 3.3	0.5
1930 - 1940	0.4	5.7	0.7	4.7	- 0.3	2.8	7.2	3.9
1940 - 1950	- 0.5	--	- 1.4	--	1.7	- 1.0	--	--
1950 - 1960	3.6	9.2	4.6	6.3	- 1.7	- 4.7	- 1.5	7.1
1960 - 1970	2.2	11.9	8.9	11.5	- 3.6	2.9	2.1	10.0
Average	1.9	5.4	2.0	5.7	- 0.6	2.1	0.4	3.8

	Exogenous variables						
	$\dot{K}$	$\dot{L}$	$\dot{Q}$	$\dot{B}$	$\dot{T}_1$	$\dot{T}_2$	$\dot{a}$
1880 - 1890	2.3	0.5	0.9	0.4	3.2	1.7	3.2
1890 - 1900	2.6	0.6	1.0	0.6	1.3	2.0	- 2.5
1900 - 1910	3.6	0.4	1.2	0.7	1.8	0.2	- 0.4
1910 - 1920	5.3	0.6	1.2	0.7	3.5	- 0.7	0.5
1920 - 1930	4.2	0.9	1.6	- 0.1	1.0	- 0.3	- 2.6
1930 - 1940	4.2	1.5	1.1	0.3	0.4	2.2	1.0
1940 - 1950	--	0.2	1.6	- 0.4	- 1.2	--	--
1950 - 1960	6.1	2.2	1.2	0.4	4.1	4.1	- 1.7
1960 - 1970	11.3	1.3	1.1	- 0.5	0.1	6.5	- 3.6
Average	5.0	0.9	1.2	0.2	1.6	2.0	- 0.8

Sources:
$\dot{Y}_1$ - Ohkawa and Shinohara; $\dot{Y}_2$ - LTES 1, Ohkawa and Shinohara, and $\dot{Y}_1$; $\dot{K}_1$ - Yamada and Hayami; $\dot{K}_2$ Ohkawa and Shinohara and $\dot{K}_1$; $\dot{L}_1$ - Ohkawa and Shinohara; $\dot{L}_2$ - Ohkawa and Shinohara and $\dot{L}_1$; $\dot{P}$ - LTES I. and Ohkawa and Shinohara; $\dot{E}$ - LTES 1. and Ohkawa and Shinohara; $\dot{K}$ - Ohkawa and Shinohara; $\dot{L}$ - Ohkawa and Shinohara; $\dot{Q}$ - Ohkawa and Shinohara; $\dot{B}$ - LTES 9; $\dot{T}_1 = \dot{Y}_1 - \alpha\dot{L}_1 - \beta\dot{K}_1 - (1 - \alpha - \beta)\dot{B}$; $\dot{T}_2 = \dot{Y}_2 - \gamma\dot{L}_2 - \delta\dot{K}_2$;
$\dot{a} = \dot{Y}_1 - \dot{Q} - \eta\dot{P} - \epsilon\dot{E}$.

Table 3 Parameter Values Used in the Model

Year	(1) Labour's share in agric. output $\alpha = \frac{w_1 L_1}{P_1 Y_1}$	(2) Capital's share in agric. output $\beta = \frac{r_1 K_1}{P_1 Y_1}$	(3) Labour's share in nonagric. output $\gamma = \frac{w_2 L_2}{P_2 Y_2}$	(4) Capital's share in nonagric. output $\delta = \frac{r_2 K_2}{P_2 Y_2}$	(5) Rel. price elast. of agric. goods η	(6) Income elast. of agric. goods ϵ	(7) Prop. of labour in agric. $l_1 = \frac{L_1}{L}$	(8) Prop. of capital in agric. $k_1 = \frac{K_1}{K}$	(9) Share of income produced by agric. $\lambda = \frac{P_1 Y_1}{P'QE}$
1880	0.58	0.12	0.84	0.16	- 0.60	0.80	0.71	0.43	0.50
1885	0.57	0.12	0.84	0.16	- 0.60	0.80	0.70	0.42	0.35
1890	0.54	0.12	0.78	0.22	- 0.60	0.80	0.68	0.39	0.39
1895	0.54	0.11	0.74	0.26	- 0.60	0.80	0.66	0.37	0.33
1900	0.56	0.10	0.69	0.31	- 0.60	0.80	0.65	0.33	0.29
1905	0.55	0.11	0.65	0.35	- 0.60	0.71	0.63	0.31	0.25
1910	0.56	0.11	0.65	0.35	- 0.60	0.71	0.62	0.27	0.24
1915	0.55	0.12	0.58	0.42	- 0.60	0.71	0.57	0.23	0.22
1920	0.55	0.12	0.67	0.33	- 0.60	0.71	0.51	0.18	0.22
1925	0.59	0.11	0.67	0.33	- 0.60	0.71	0.48	0.15	0.22
1930	0.61	0.12	0.64	0.36	- 0.60	0.71	0.47	0.13	0.13
1935	0.55	0.13	0.62	0.38	- 0.60	0.71	0.44	0.11	0.14
1940	0.55	0.10	0.58	0.42	- 0.60	0.71	0.40	0.09	0.13
1945	0.55	0.10	0.58	0.42	- 0.60	0.80	0.44	0.10	0.14
1950	0.55	0.10	0.58	0.42	- 0.60	0.71	0.44	0.09	0.14
1955	0.65	0.12	0.75	0.25	- 0.60	0.61	0.37	0.09	0.16
1960	0.57	0.13	0.70	0.30	- 0.60	0.61	0.30	0.08	0.09
1965	0.60	0.16	0.71	0.29	- 0.60	0.61	0.23	0.07	0.06
1970	0.60	0.16	0.70	0.30	- 0.60	0.61	0.16	0.06	0.06

Sources:
Columns 1 and 2 are from data in Yamada and Hayami, Columns 3 and 4 are from Minami and Ono. Column 5 is from the data series used for equation (1). Column 6 is from Ohkawa. Columns 7, 8 and 9 are from Ohkawa and Shinohara.

By multiplying the GRM of each decade by the corresponding decade rates of change of the exogenous varibles as they occured in Japan (Table 2), one can measure the contribution of the exogenous variables to the observed rate of changes of the endogenous variables, i. e.,

$$(\partial \dot{E}/\partial \dot{L})_t \dot{L}_t = (A^{-1})_{8,4} \dot{L}_t = ELC,$$

where ELC (E for income, L for labor, C for contribution) is the measured contribution of the growth rate of labor to per capita income growth at time t.

The structural parameters used for the A matrix are shown in Table 3. Throughout the period the nonagricultural sector is more labor intensive than the agricultural sector ($\gamma > \delta$). Also, agriculture's share of total income was 50 % in 1880 and decline steadily to 6 % in 1970.

The rates of change of the exogenous variables are summarized in Table 2. The rates of technical change were measured using equations (14) and (15) of Table 1. This is the familiar Solow approach. The average rate of nonagricultural technical change exceeded the agricultural rate of technical change, but the former fluctuated much more than the latter. Population growth rates were low and larger after the turn of the century than before. The labor force grew at about the same average rate as did population, but these rates differed strongly in the short run.

Table 2 also summarizes the rates of change of the endogenous variables. The decline of agriculture's share in income is shown clearly in the absolute decline of the agricultural labor force and the much slower rise of agricultural capital than of nonagricultural capital. Terms of trade turned in favor of agriculture throughout most of the period.

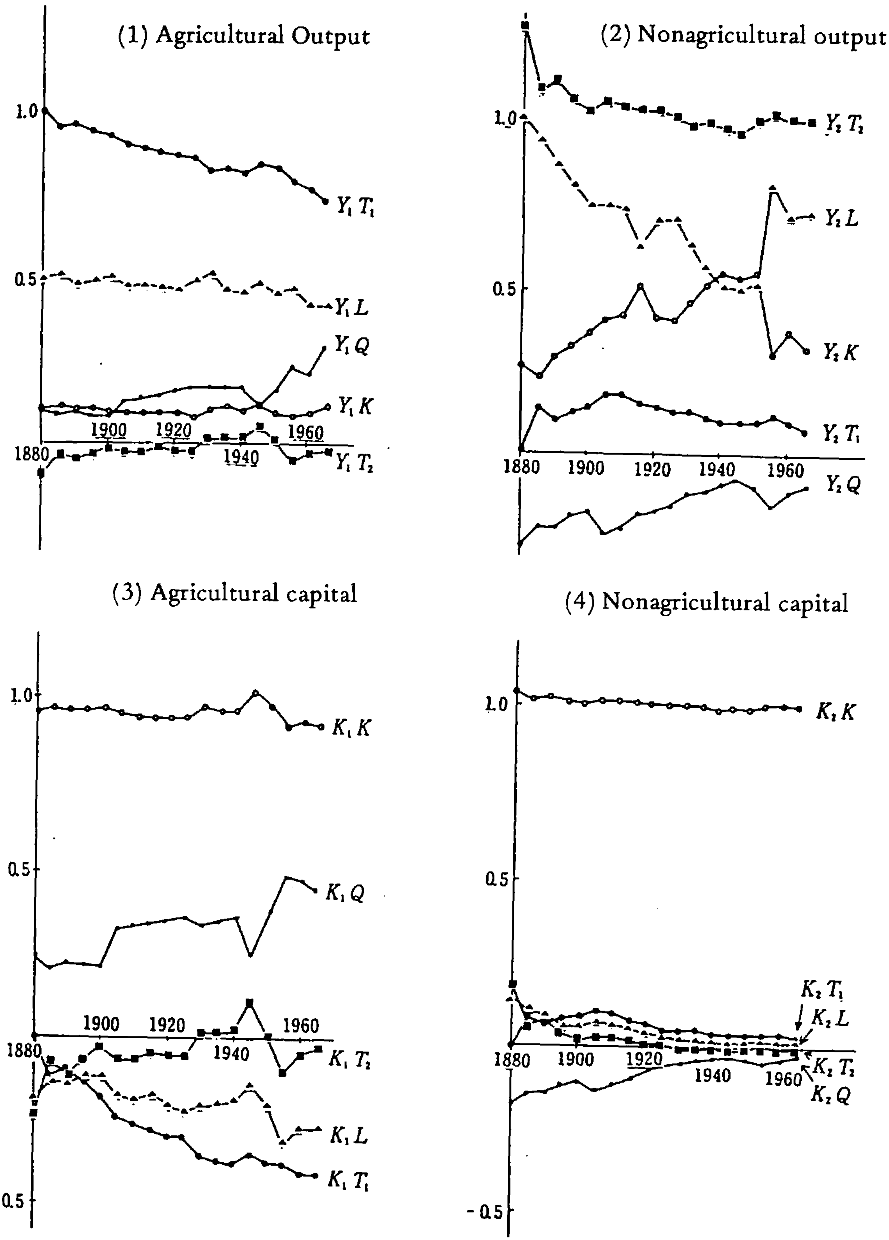
IV. Results

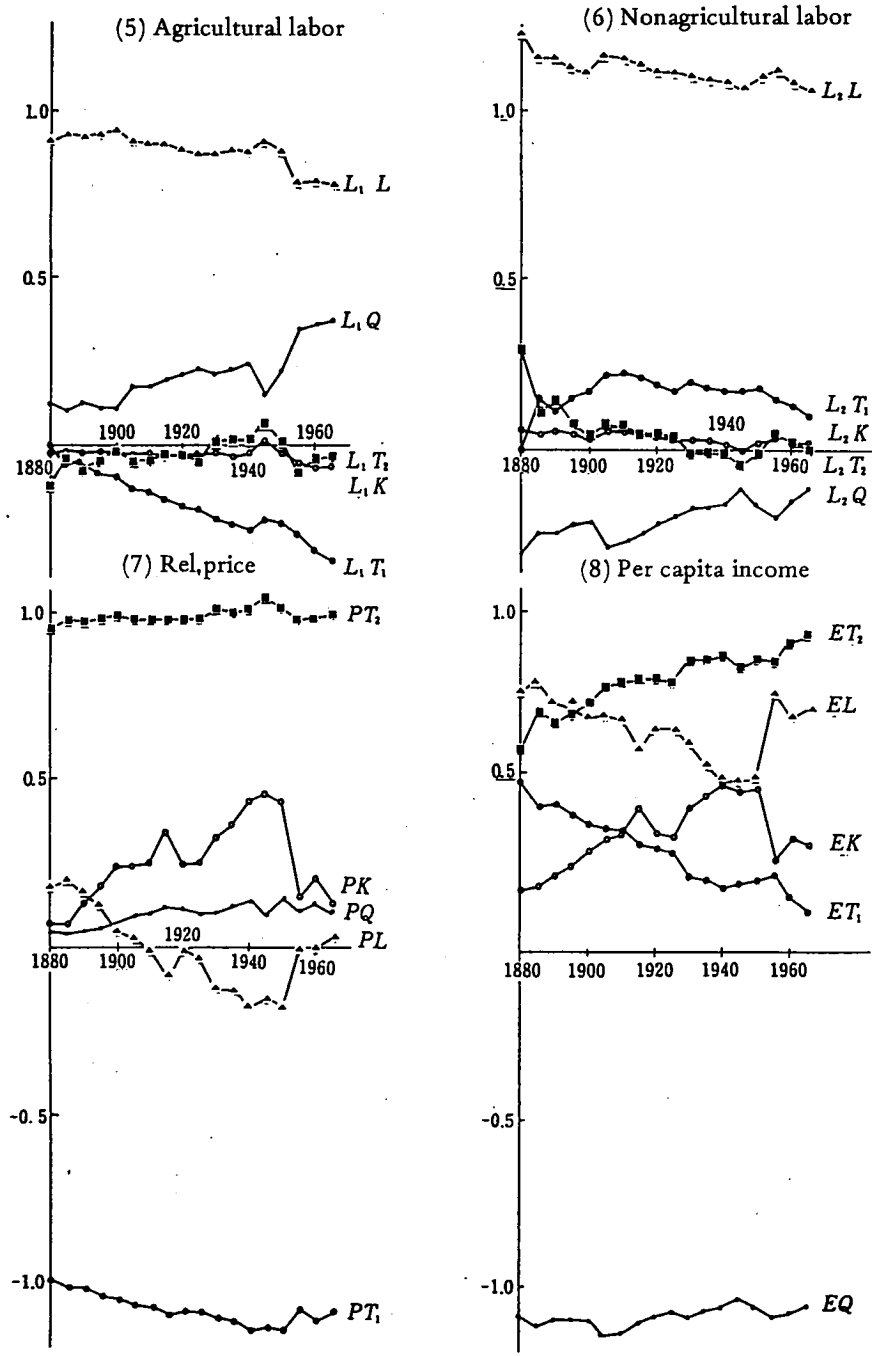
Figure 2 shows GRMs for five exogenous variables such as agricultural and nonagricultural technical change, population, labor and capital on each of the eight endogenous variables for each five-year period from 1880 to 1970. Here we focus only the effect of technical change on eight endogenous variables and the effect of population on per capita income.

With respect to the agricultural sector, agricultural technical change (T_1) has a large influence on output (Y_1). Its influence is greatest in 1880, where a one-percent increase in T_1 causes a 1.00 percent increase in Y_1. The influence of nonagricultural technical change (T_2) on Y_1 is negative or zero. Agricultural capital (K_1) and labor (L_1) are pushed by agricultural technical change (K_1T_1, $L_1T_1 < 0$) and are pulled by nonagricultural technical change ($K_1T_2, L_1T_2 < 0$) to the nonagricultural sector.

With respect to the nonagricultural sector, nonagricultural technical change (T_2) has a large influence on output (Y_2). Its influence is greatest in 1880, where a one-percent increase in T_2 causes a 1.28 percent increase in Y_2. Agricultural technical change has a small, positive influence on Y_2. Nonagricultural

Figure 2: Growth Rate Multiplier




(5) Agricultural labor
$L_1 L$
$L_1 Q$
$L_1 T_2$
$L_1 K$
$L_1 T_1$
(6) Nonagricultural labor
$L_2 L$
$L_2 T_1$
$L_2 K$
$L_2 T_2$
$L_2 Q$
(7) Rel, price
PT_2
PK
PQ
PL
PT_1
(8) Per capita income
ET_2
EL
EK
ET_1
EQ
1880
1900
1920
1940
1960

capital (K_2) and labor (L_2) are positively influenced by both agricultural and nonagricultural technical change (K_2T_1, L_2T_1, K_2T_2, $L_2T_2 > 0$), corresponding to the push and pull effects of T_1 and T_2.

The relative (agricultural/nonagricultural) price, P, is strongly influenced by technical change in both sectors. The influence of agricultural technical change is negative ($PT_1 < 0$), while the influence of nonagricultural technical change is positive ($PT_2 > 0$).

Per capita income is increased by technical change in the agricultural sector ($ET_1 > 0$) and the nonagricultural sector ($ET_2 > 0$), the latter having the strongest influence. Note that ET_1 decreases over time, whereas ET_2 increases over time.

Population growth has a more detrimental effect on per capita income the smaller the nonagricultural sector out of which resources must be drawn for an increased food production (see EQ in Figure 2).

The histogram of Figure 3 shows the historical average growth rates of the 8 endogenous variables as the sum of all the contributions of each exogenous variable in each decade. We have 8 exogenous variables but only 5 principal exogenous variables (sectoral technical change T_i, total capital K, total labor L and population Q) are shown in Figure 3 to avoid complicating the picture.

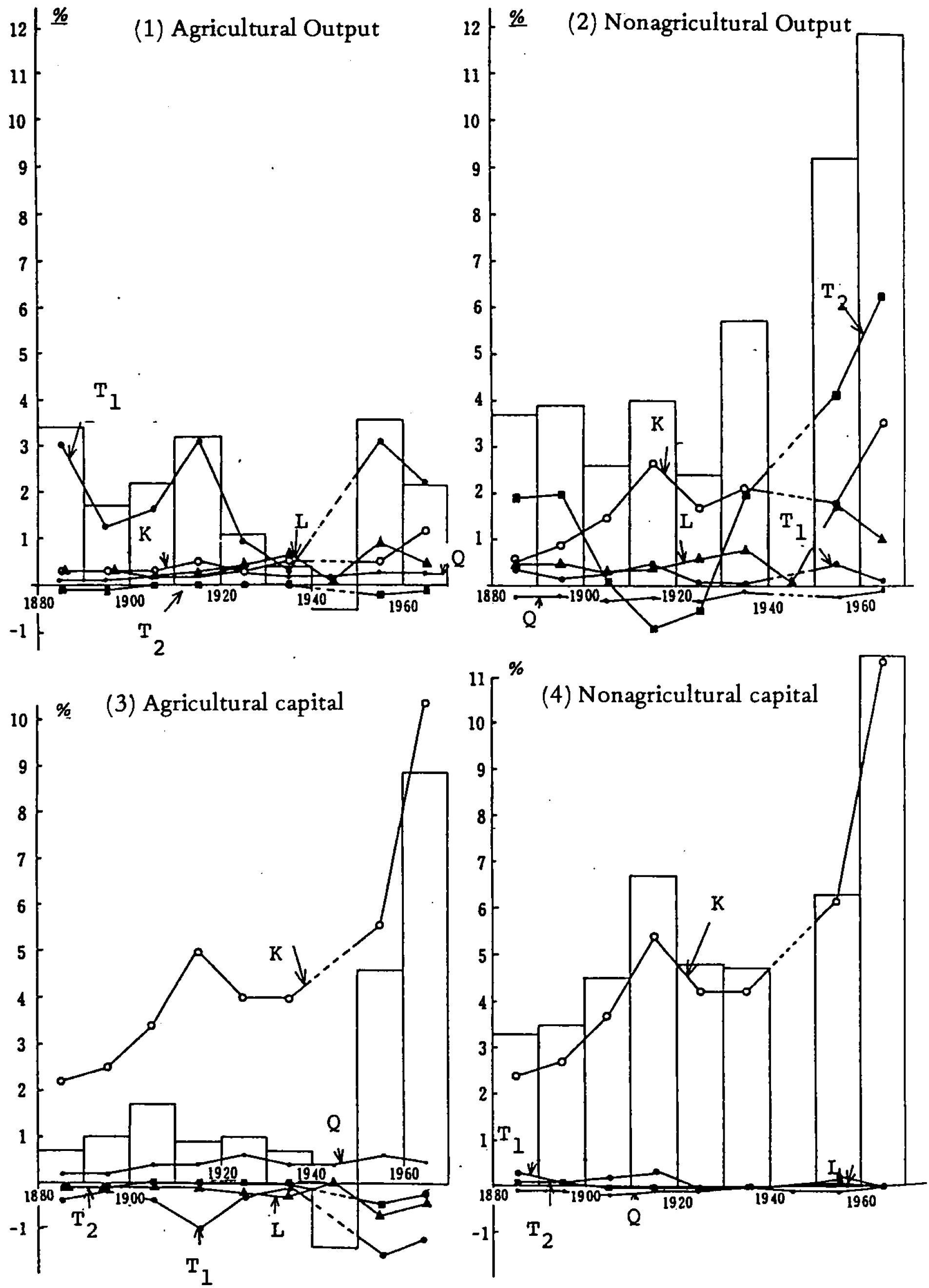
First observe the calculated results of Figures 2, 3. Very briefly, it is seen that with respect to;

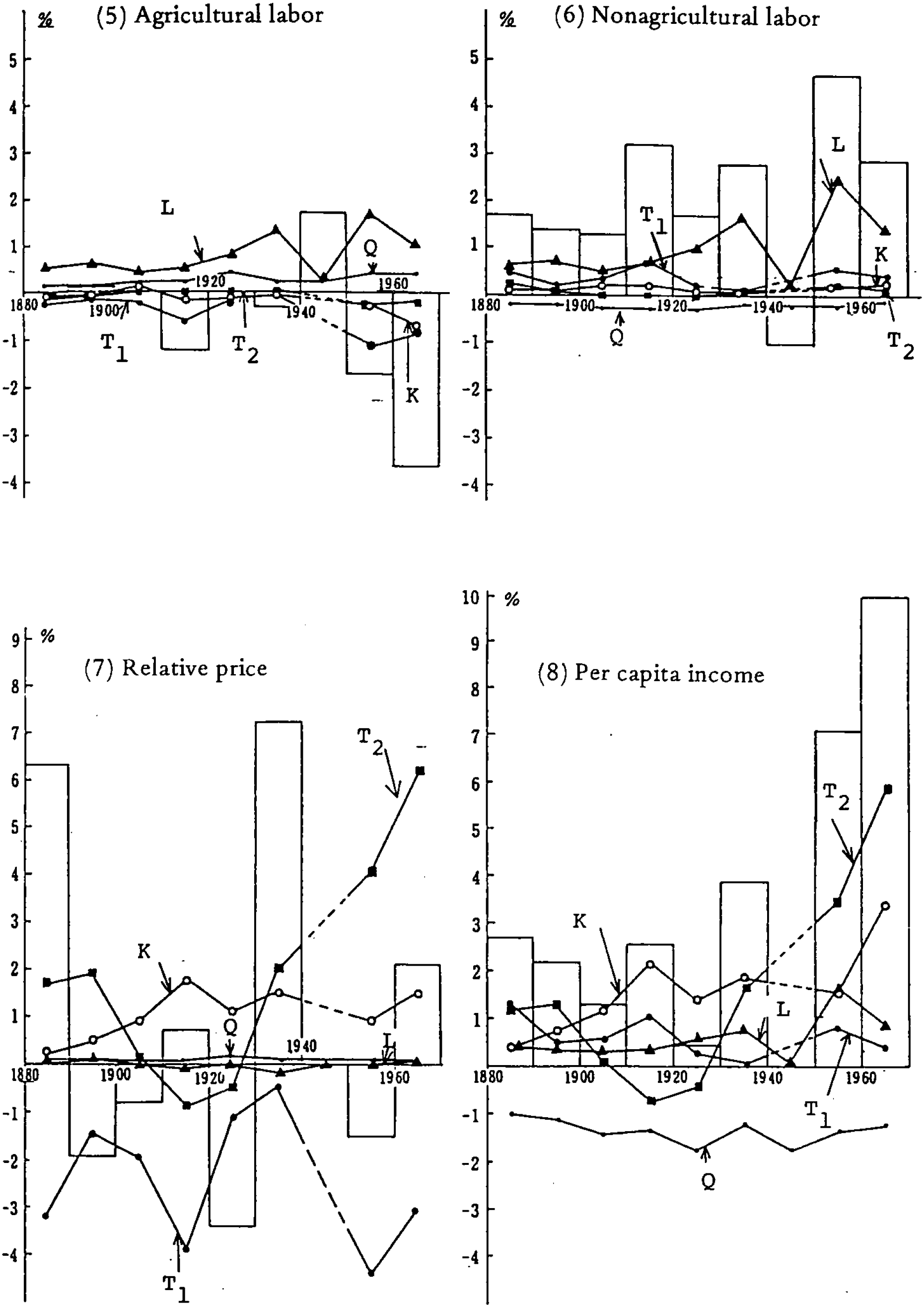
Agricultural output, the largest contribution is agricultural technical change with total labor, total capital and population following in importance. This is almost the same order as the GRM's. The order of total capital and total labor are reverse from the order of the GRM in Figure 2, since the historical growth rate of total capital is larger than the growth rate of total labor as Table 2 shows. The contribution of nonagricultural technical change has a zero or negative value in each decade;

Nonagricultural output, nonagricultural technical change makes the largest contribution but the contribution varies widely. Total capital, total labor and agricultural technical change follow in importance with the order of the contribution of total capital and total labor are reversed from the order of the GRM in Figure 2. This comes from the same reasons as with agricultural output. Population growth makes a small negative contribution. Agricultural technical change on the other hand makes a positive contribution to the growth of nonagricultural output, especially in the 1910's and 1920's when agricultural technical change makes a larger contribution than nonagricultural technical change – this in contrast to the negative contribution of nonagricultural technical change to the agricultural output;

Agricultural capital stock, the largest contributor is, of course, total capital. Other contributions are fairly small. The effect (GRM) and the contributions of technical change in both sectors are negative – technical change pushes and draws agricultural factor inputs to the nonagricultural sector;

Figure 3: The Contribution of 5 Exogenous Variables to the 8 Endogenous Variables




%
(5) Agricultural labor
5
4
3
2
1
-1
-2
-3
-4
1880
1900
1920
1940
1960
L
Q
T1
T2
K
%
(6) Nonagricultural labor
5
4
3
2
1
-1
-2
-3
-4
1880
1900
1920
1940
1960
L
T1
K
Q
T2
9
%
(7) Relative price
8
7
6
5
4
3
2
1
-1
-2
-3
-4
1880
1900
1920
1940
1960
T2
K
Q
L
T1
10
%
(8) Per capita income
9
8
7
6
5
4
3
2
1
-1
-2
-3
-4
1880
1900
1920
1940
1960
T2
K
L
T1
Q

Nonagricultural capital stock, the largest effect and contributor is, of course, total capital. Agricultural technical change, nonagricultural technical change and total labor follow in markedly smaller contributions. However these small positive effects and contributions correspond to the pushing and pulling effect of technical change as stated above. Finally population has a negative effect making an opposite contribution as compared with technical change;

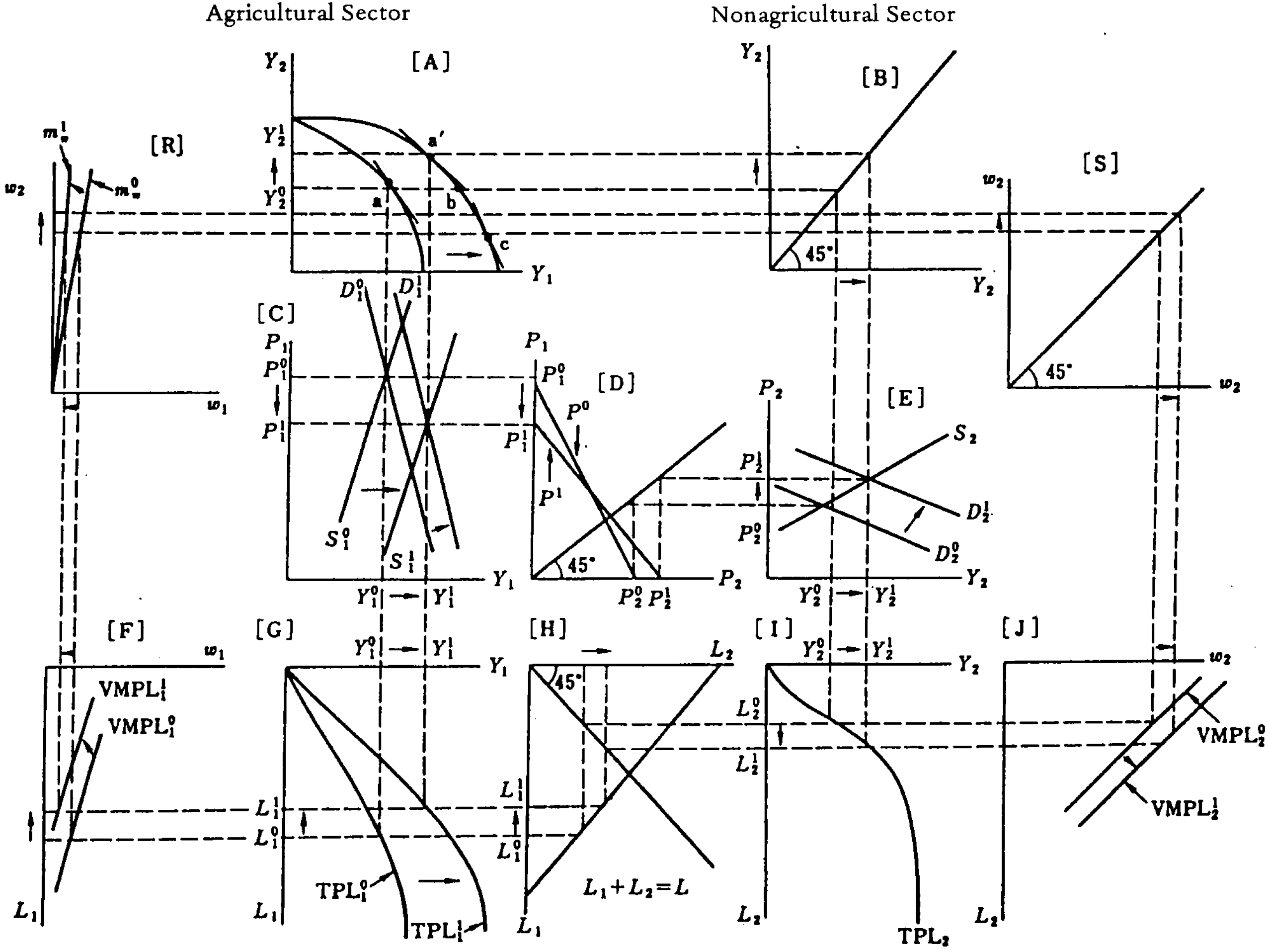
Agricultural labor, total labor makes the largest contribution (and effect) with population following. The rest of the variables have a negative effect and push and pull agricultural labor to the nonagricultural sector, especially the phenomenon of agricultural technical change;

Nonagricultural labor, total labor again has the largest effect and contribution. Agricultural technical change, total capital and nonagricultural technical change follow in importance. This also corresponds to the pushing and pulling effect of technical change. Population obviously has a negative effect and contribution as stated above;

Relative price (ag. price/nonag. price), nonagricultural technical change makes the largest positive effect and contribution. Agricultural technical change makes the largest negative effect and contribution. The contributions of the other variables are very small except for the fairly large contribution of total capital (see Johnson (1));

Per capita income, nonagricultural technical change has the largest effect and contribution as a whole, due to the fact that the GRM of nonagricultural technical change has the largest value and the historical rate of technical change in nonagriculture is fairly large, especially after World War II. However its contribution depends on the decade and shows large variation. On the other hand the contribution of agricultural technical change is fairly stable and almost the same size as the contribution of total labor on average. Also the contribution of agricultural technical change is relatively larger in the early stage of economic development in Japan. This is because the GRM of agricultural technical change is larger in this period. The contribution of capital is somewhat larger than that of labor. Note that the GRM of labor was larger than the GRM of capital since the historical growth rate of capital was very large indicated in Figure 1. Population has, of course, a negative effect on per capita income. However the net contribution of population which is the sum of the contributions of population and of labor has a much smaller negative value. In the ordinary model which treats labor and population together, we can only obtain the net contribution of population. However this model allows us to evaluate the contributions of population and labor independently and see the effect of the labor participation rate as well.

Figure 4: The Push Effect of Agricultural Technical Change



V. Asymmetric Effect of Technical Change in both Sectors

As shown above we understood that there was an asymmetric effect of technical change in both sectors.

Figure 4 describes the effects of agricultural technical change (T_1) and Figure 5 describes the effects of nonagricultural technical change (T_2) on both the agricultural and nonagricultural sectors. To simplify the graphic models, it is assumed that labor is the only resource, as the treatment of capital would be analogous.

T_1 increases the productivity of agricultural labor, shown in Figure 4 as an upward movement of the total productivity curve of agricultural labor, from TPL_1^0 to TPL_1^1 in panel G. T_1 is assumed to have no effect on the total productivity curve of nonagricultural labor, TPL_2 in panel I. The increased productivity of agricultural labor implies an outward shift in the production possibility curve, depicted in panel A. This means that more Y_1 and Y_2 can be produced given the total amount of labor available (L).

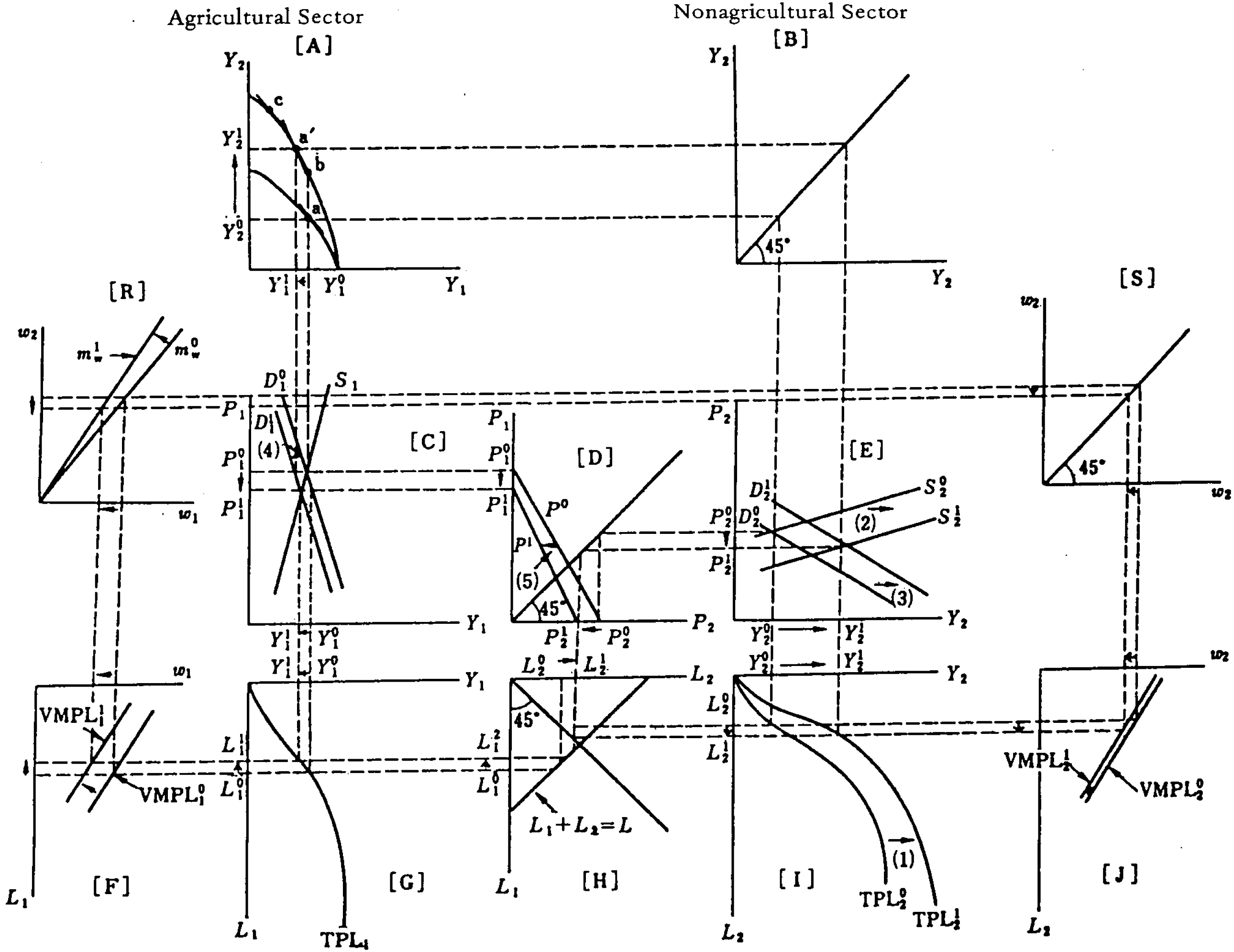
The supply and demand effects of T_1 on the agricultural and nonagricultural sectors are shown in panels C and E respectively. When T_1 occurs, the agricultural supply curve shifts to the right, from S_1^0 to S_1^1 (panel C). Agricultural demand is also affected. T_1 increases per capita income and increased per capita income results in increased demand for agricultural and nonagricultural products. For agricultural products, this is shown as a shift in the demand curve from D_1^0 to D_1^1 (panel C). The amount of Y_1 produced increases from Y_1^0 to Y_1^1 and the priced falls from P_1^0 to P_1^1.

T_1 results in two cross-effects on the nonagricultural sector, both on the demand side: a decrease in demand because the fall in the price of agricultural goods has increased the relative price of nonagricultural goods (the price effect) and an increase in demand due to the increase in per capita income noted above (the income effect). Given the relatively high income elasticity for nonagricultural products, the positive income effect outweighs the negative price effect, resutling in a rightward shift in demand, from D_2^0 to D_2^1 (panel E). This increase in demand results in an increase of Y_2 produced (from Y_2^0 to Y_2^1) and increase in its price (from P_2^0 to P_2^1).

The decreased price of Y_1 and increased price of Y_2 cause the relative (agricultural/nonagricultural) price (P) to decline. This is shown in panel D where the relative price line becomes less steep (from P^0 to P^1). The optimal combination of Y_1 and Y_2 moves from point a to a' in panel A, where the new production possibility curve is tangent to the new price line. More of both Y_1 and Y_2 are produced.

The increased productivity of agricultural labor (L_1) means the increase in Y_1 can be produced with less labor, shown by a decrease in L_1 from L_1^0 to L_1^1 in panel G. Since the productivity of nonagricultural labor (L_2) has not incre-

Figure 5: The Pull Effect of Nonagricultural Technical Change



ased, the increase in Y_2 produced requires an increase in L_2, from L_2^0 to L_2^1 in panel I. These changes in sectoral requirements of labor simultaneously change sectoral demand for labor. The value of marginal productivity of L_1 declines relative to that of L_2. This is shown in Figure 4, assuming $VMPL_1$ shifts downward (from $VMPL_1^0$ to $VMPL_1^1$ in panel F) and $VMPL_2$ shifts upward (From $VMPL_2^0$ to $VMPL_2^1$ in panel J). The increased demand for L_2 relative to L_1 leads to increased wages for the former relative to the latter, shown as a decline in the relative wage rate from m_w^0 to m_w^1 in panel R. The new wage rates and new values of marginal productivities for L_1 and L_2 are equated in panels F and J respectively. The result is a shift in agricultural labor ($L_1^0 - L_1^1$ in panel G) to the nonagricultural sector. Panel H ensures that the sum of labor used in each sector equals the total amount available (L).

As for the effects of nonagricultural technical change (T_2), a similar graphic model is given in Figure 5, again assuming labor to be the only resource. T_2 increases the productivity of nonagricultural labor, shown as an upward shift of its total productivity curve, from TPL_2^0 to TPL_2^1 in panel I. T_2 is assumed to have no effect on the total productivity curve of agricultural labor, TPL_1 in panel G.

T_2 causes the nonagricultural supply curve to shift to the right, from S_2^0 to S_2^1 (panel E). T_2 increases profits in the nonagricultural sector, leading to increased per capita income and increased demand for agricultural and nonagricultural products. For nonagricultural products, this is shown as a shift in the demand curve from D_2^0 to D_2^1 (panel E). The amount of Y_2 produced increases from Y_2^0 to Y_2^1 and the price falls from P_2^0 to P_2^1.

Regarding T_2's effects on the agricultural sector, the same two cross-effects on demand (as T_1 exerted on the nonagricultural sector) occur. Agricultural demand is affected negatively by the price effect, since agricultural goods are now priced higher relative to nonagricultural goods. It is affected positively by the income effect, given increased per capita income resulting from T_2. Due to the relatively low income elasticity of agricultural products, the positive income effect is outweighed by the negative price effect, resulting in a leftward shift of the demand curve, from D_1^0 to D_1^1 in panel C. The decrease in demand results in a decrease of Y_1 produced (from Y_1^0 to Y_1^1) and a fall in price (from P_1^0 to P_1^1). The fall in price of agricultural products is less than that of nonagricultural products causing P to increase. This is shown in panel D, where the relative price line becomes steeper (from P^0 to P^1).

The decreased amount of Y_1 produced requires less L_1, shown as a decrease of L_1 from L_1^0 to L_1^1 in panel G. Despite the increased productivity of L_2, the large increase in Y_2 produced requires more L_2, shown as an increase from L_2^0 to L_2^1 in panel I. These changes in sectoral requirements of labor simultaneously change sectoral labor demand. The value of the marginal productivity of L_1 again declines relative to that of L_2. This is shown in Figure 5 (panels F an J), assuming both $VMPL_1$ and $VMPL_2$ shift downwards, the former shifting relatively more. The lowered demand for L_1 relative to L_2 leads to a decline in the relative wage rate, from m_w^0 to m_w^1 in panel R. The new wage rates and new values of marginal productivities for L_1 and L_2 are equated in panels F and J, causing a shift in agricultural labor to the nonagricultural sector (L_1^0 - L_1^1 in panel G).

In summary, one can compare and contrast the effects of T_1 and T_2. Their effects on labor also apply to capital. The direct effects of T_1 and T_2 are similar in that they lower product price (increased supply exceeds increased demand) and increase the marginal productivity of labor in their respective sectors.

With respect to cross-effects, T_1 and T_2 affect demand in the other sector in similar ways but different directions. T_1 leads to increases in nonagricultural demand and hence increased output in the nonagricultural sector. T_2, on the other hand, results in decreases in agricultural demand, causing a decline in agricultural output. Both T_1 and T_2 lead to increases in the VMP of L_2 relative to that of L_1.

VI. Conclusion

Some of main conclusions are summarized as follows. (1) Population growth has a more detrimental effect on per capita income the smaller the nonagricultural sector out of which resources must be drawn for an increased food production. (2) Technical change in Japan has contributed more to growth than traditional factors. Overall, nonagricultural technical change has contributed more to per capita income than agricultural technical change. However, the contribution of the latter was more stable from decade to decade and particularly important during the early economic development and depression periods. (3) Technical change in agriculture tends to push resources out of agriculture, while nonagricultural technical change tends to draw resources into nonagriculture. The asymmetric effect of technical change is due to the low price and income elasticities for agricultural goods.

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